APPLICATION NOTE

Application of the TEA1118 and TEA1118A versatile cordless transmission circuits

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Philips
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Abstract

The TEA1118 and TEA1118A are bipolar transmission circuits for use in cordless telephone sets or answering machines. They are part of TEA111x family.

A detailed description of the circuit blocks of the TEA1118 and TEA1118A and advices on adjustments are contained in this report.

APPLICATION NOTE

Application of the TEA1118 and TEA1118A versatile cordless transmission circuits

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Summary

A detailed description of the blocks of both ICs TEA1118 and TEA1118A is given. The possible settings to adjust the DC and transmission characteristics are explained.

The TEA1118 and the TEA1118A incorporate a transmit amplifier and a receive amplifier, the TEA1118A incorporates also a DTMF amplifier.

An evaluation board for the TEA1118A, which can be used for the TEA1118, is available.

The general notation in this report for both ICs is **TEA1118/A.**

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CONTENTS

1. INTRODUCTION 7

2. BLOCK DIAGRAMS AND PINNINGS 8

3. DESCRIPTION OF THE TEA1118/A 12
3.1 DC characteristics and supply block 13
3.1.1 DC characteristics 13
3.1.2 Supply for peripherals 16
3.2 Set impedance 17
3.3 Transmit amplifier 18
3.4 TMUTE function (TEA1118A only) 22
3.5 Receive amplifier 23
3.6 Automatic gain control 26
3.7 DTMF amplifier (TEA1118A only) 27
3.8 MUTE function (TEA1118A only) 29
3.9 Anti-sidetone network 31
3.9.1 TEA106x or TEA111x family bridge 31
3.9.2 Wheatstone bridge 32

4. APPLICATION COOKBOOK 33

5. EXAMPLE OF APPLICATION 35

6. ELECTROMAGNETIC COMPATIBILITY 37

7. REFERENCES 38

LIST OF FIGURES

FIG. 1 TEA1118 BLOCK DIAGRAM 8
FIG. 2 TEA1118A BLOCK DIAGRAM 9
FIG. 3 TEA1118 PINNINGS 10
FIG. 4 TEA1118A PINNINGS 11
FIG. 5 BASIC APPLICATION FOR MEASUREMENTS 12
FIG. 6 DC CHARACTERISTICS CONFIGURATION 13
FIG. 7 ICC VERSUS VCC 14
FIG. 8 MAIN VOLTAGES VERSUS LINE CURRENT 14
FIG. 9 LOW VOLTAGE BEHAVIOR IN LINE POWERED CONDITIONS 15
FIG. 10 LOW VOLTAGE BEHAVIOR WITH EXTERNAL POWER SUPPLY 15
FIG. 11 INFLUENCE OF AN RVA RESISTOR BETWEEN REG AND SLPE ON VLN AT 15MA 16
FIG. 12 INFLUENCE OF RSLPE ON THE DC CHARACTERISTICS 16
FIG. 13 EQUIVALENT SET IMPEDANCE 17
FIG. 14 TRANSMIT CHANNEL 18
FIG. 15 TRANSMIT GAIN VERSUS RGAT CONNECTED BETWEEN GAT AND REG 19
FIG. 16 TRANSMIT GAIN VERSUS FREQUENCY: INFLUENCE OF TEMPERATURE 19
FIG. 17 DISTORTION ON LINE VERSUS TRANSMIT SIGNAL AT NOMINAL GAIN ON TEA1118/A 20
FIG. 18 DISTORTION ON THE LINE VERSUS TRANSMIT SIGNAL AT 5 DB GAIN ON TEA1118 20
FIG. 19 DISTORTION OF LINE SIGNAL AT ILINE = 4 MA WITH EXTERNAL 3.3 V POWER SUPPLY 21
FIG. 20 TRANSMIT NOISE VERSUS LINE CURRENT 21
FIG. 21 COMMUN MODE REJECTION RATIO ON TRANSMIT 22
FIG. 22 TRANSMIT GAIN AND TMUTE INPUT CURRENT VERSUS TMUTE INPUT VOLTAGE 22
FIG. 23 TRANSMIT GAIN REDUCTION IN TMUTE CONDITION 23
FIG. 24 RECEIVE CHANNEL 23
FIG. 25 RECEIVE GAIN VERSUS RGAR CONNECTED BETWEEN GAR AND QR 24
FIG. 26 RECEIVE GAIN VERSUS FREQUENCY AND TEMPERATURE 25
FIG. 27 DISTORTION ON QR VERSUS INPUT SIGNAL ON IR 25
FIG. 28 DISTORTION ON QR VERSUS LEVEL WITH 450 Ω LOAD 26
FIG. 29 NOISE ON QR 26
FIG. 30 AGC ON THE TRANSMIT GAIN VERSUS LINE CURRENT AND RAGC 27
FIG. 31 DTMF CHANNEL OF THE TEA1118A 28
FIG. 32 DTMF GAIN VERSUS FREQUENCY AT DIFFERENT TEMPERATURES 29
FIG. 33 DISTORTION OF THE DTMF SIGNAL ON LINE VERSUS INPUT SIGNAL 29
FIG. 34 TRANSMIT GAIN AND MUTE INPUT CURRENT VERSUS MUTE INPUT VOLTAGE 30
FIG. 35 TRANSMIT AND RECEIVE GAIN REDUCTION IN MUTE CONDITION ON THE TEA1118A 30
FIG. 36 TEA106X ORTEA111X FAMILY ANTI-SIDETONE BRIDGE (LEFT) AND WHEATSTONE BRIDGE (RIGHT) 31
FIG. 37 EQUIVALENT AVERAGE LINE IMPEDANCE 32
FIG. 38 BASIC APPLICATION OF THE TEA1118A 36

1. INTRODUCTION

The TEA1118/A offer all the transmit, receive and line interface functions required in cordless telephone sets or in answering machines. They perform the interface between the line and the RF interface of a cordless telephone set or between the line and the codecs of a digital answering machine.

Furthermore, the TEA1118A includes a DTMF amplifier for dialling. The selection between the transmit amplifier and the DTMF amplifier is made with a MUTE or a TMUTE function. The MUTE function switches-off both the transmit and the receive amplifiers while the TMUTE switches-off only the transmit amplifier, both switch-on the DTMF amplifier.

The TEA1118 is mainly dedicated to applications where DTMF is not necessary (eg: answering machine application) or where DTMF is provided by some other part (eg: DECT application). The TEA1118A is mainly dedicated to CTO base stations.

The report is divided into two parts: the first part, up to chapter 3, gives a detailed description of the different circuit blocks of the TEA1118/A including operating principles, settings of DC and transmission characteristics and performances of the different functions; the second part describes the consecutive steps to design and adjust applications using the TEA1118/A and introduces the demoboard.

Note: the values of parameters given in this application note are as accurate as possible, but please, refer to the last product specification for final ones.

2. BLOCK DIAGRAMS AND PINNINGS

Fig. 1 shows the block diagram of the TEA1118, fig. 2 shows the block diagram of the TEA1118A, the pinnings are shown in fig. 3 and 4.

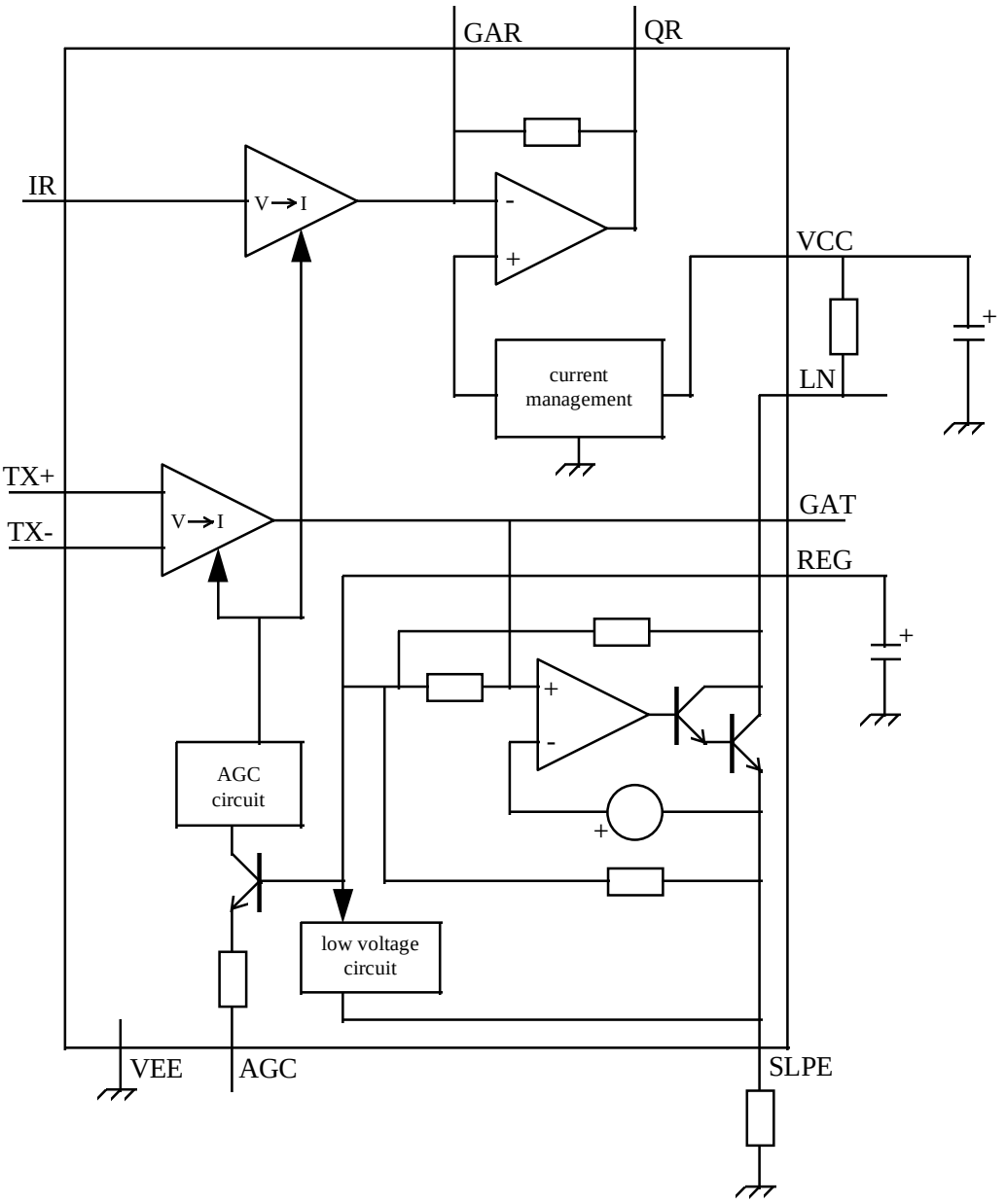

Fig. 1 TEA1118 block diagram

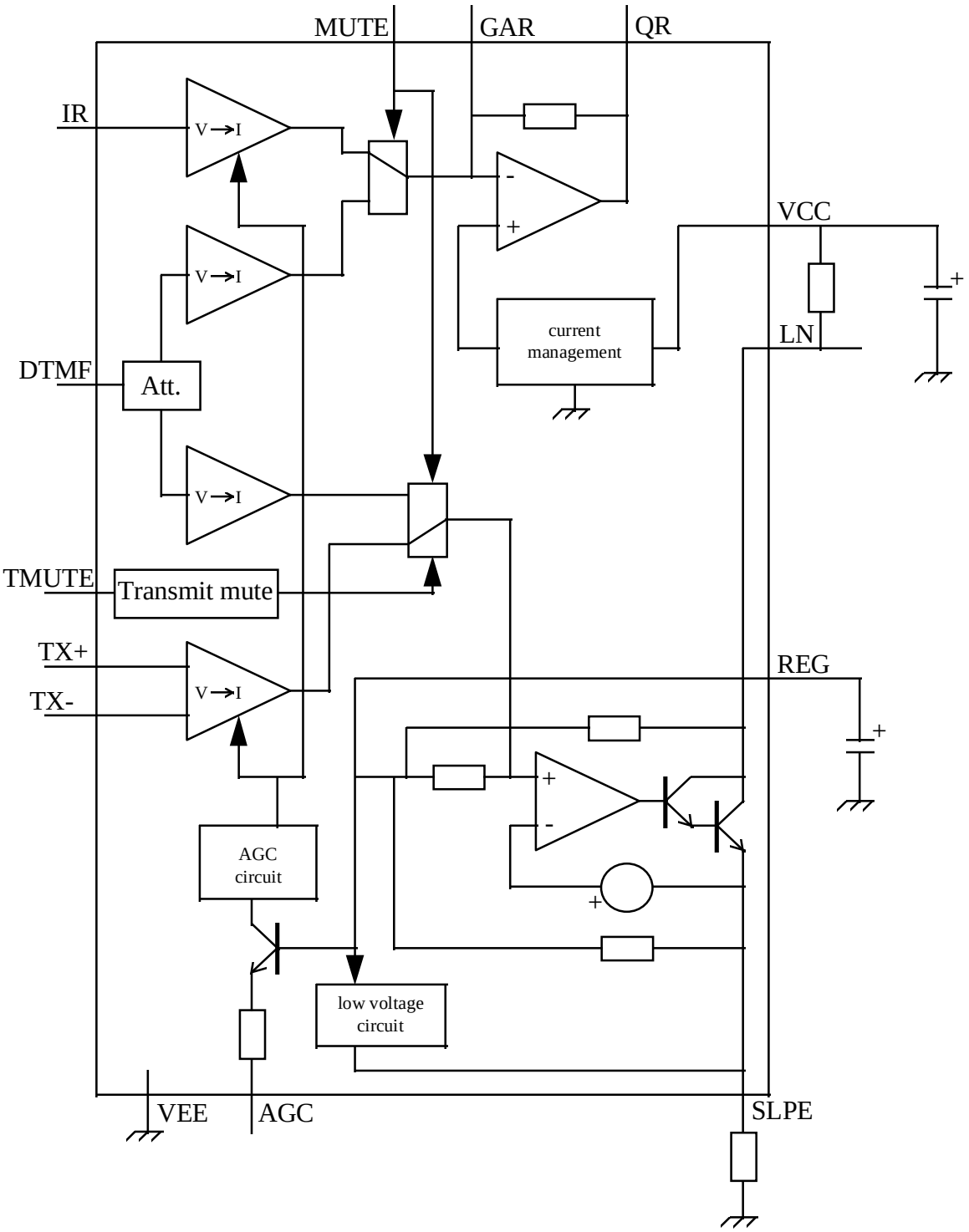

Fig. 2 TEA1118A block diagram

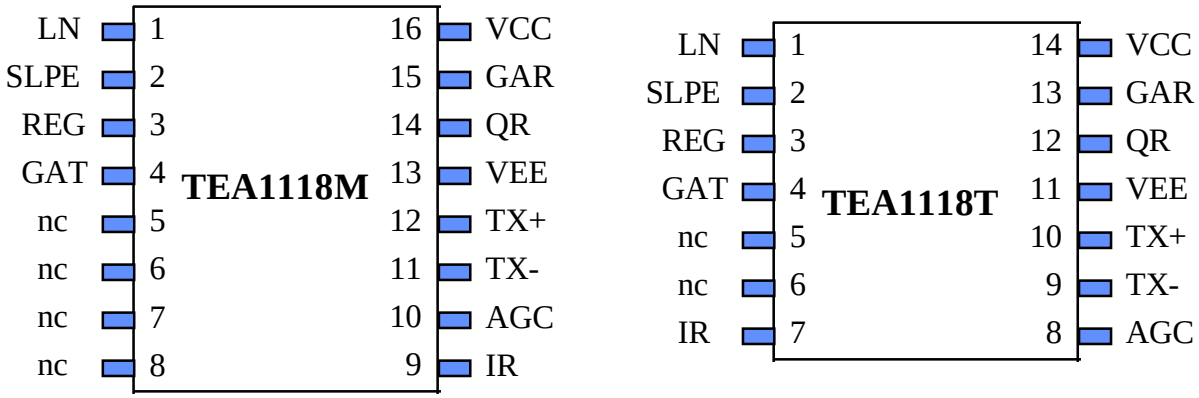

Fig. 3 TEA1118 pinnings

TEA1118M PIN	TEA1118T PIN	NAME	DESCRIPTION
1	1	LN	Positive line terminal
2	2	SLPE	Slope adjustment
3	3	REG	Line voltage regulator decoupling
4	4	GAT	Transmit gain reduction adjustment
5	5	nc	Not connected
6	6	nc	Not connected
7		nc	Not connected
8		nc	Not connected
9	7	IR	Receive amplifier input
10	8	AGC	Automatic gain control
11	9	TX-	Inverting transmit input
12	10	TX+	Non inverting transmit input
13	11	VEE	Negative line terminal
14	12	QR	Receive amplifier output
15	13	GAR	Receive gain reduction adjustment
16	14	VCC	Supply voltage for speech and peripherals

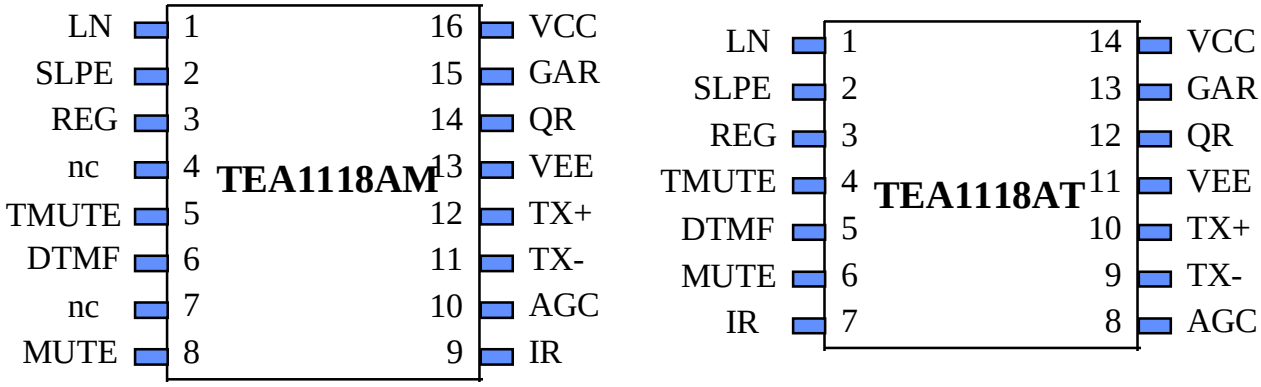

Fig. 4 TEA1118A pinnings

TEA1118AM PIN	TEA1118AT PIN	NAME	DESCRIPTION
1	1	LN	Positive line terminal
2	2	SLPE	Slope adjustment
3	3	REG	Line voltage regulator decoupling
4		nc	Not connected
5	4	TMUTE	Transmit mute input
6	5	DTMF	Dual-tone multifrequency input
7		nc	Not connected
8	6	MUTE	Mute input
9	7	IR	Receive amplifier input
10	8	AGC	Automatic gain control
11	9	TX-	Inverting transmit input
12	10	TX+	Non inverting transmit input
13	11	VEE	Negative line terminal
14	12	QR	Receive amplifier output
15	13	GAR	Receive gain reduction adjustment
16	14	VCC	Supply voltage for speech and peripherals

3. DESCRIPTION OF THE TEA1118/A

All the curves shown in this section result from measurement of typical samples. All the component names refer to the basic application of the ICs shown in fig. 5.

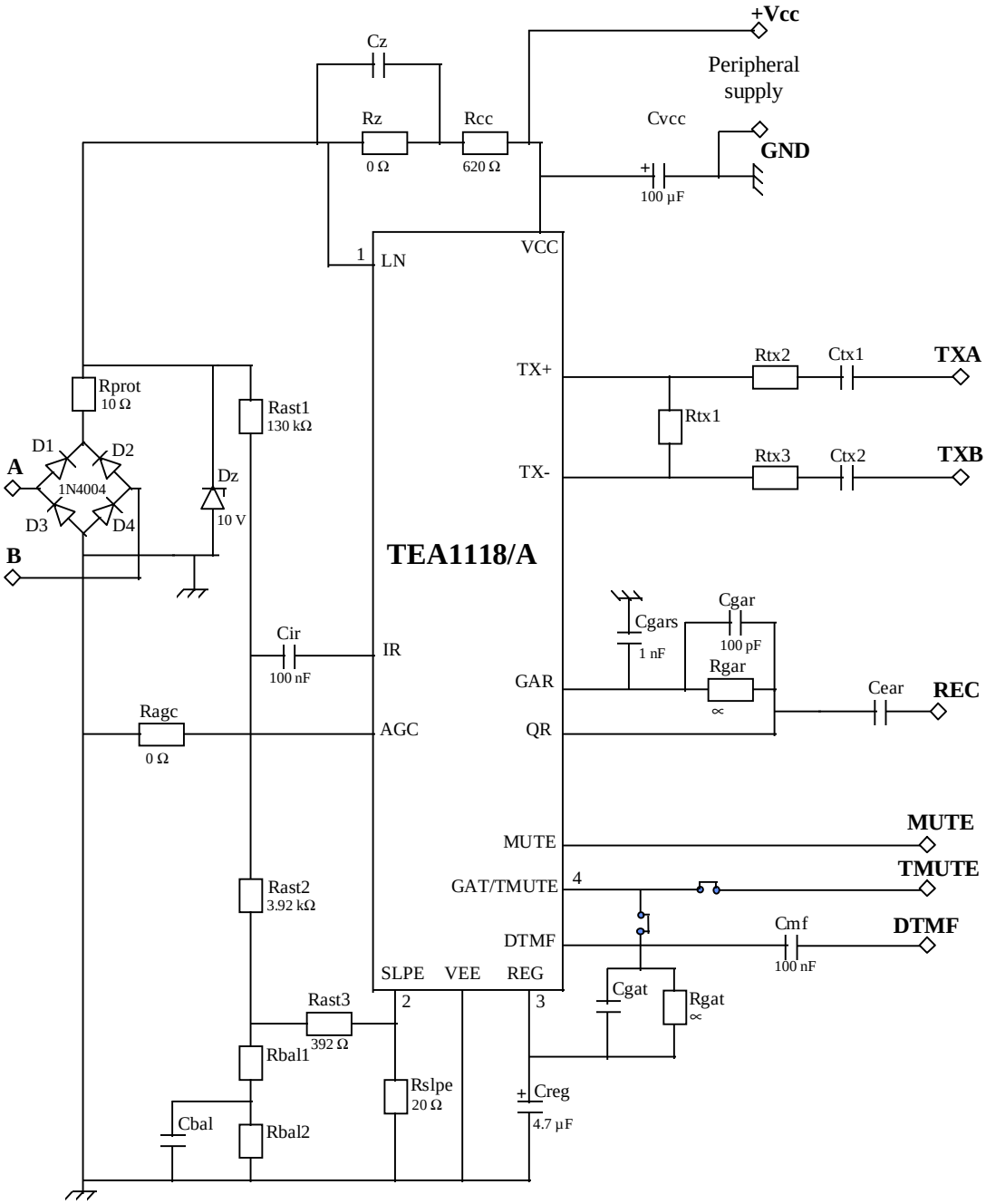

Fig. 5 Basic application for measurements

3.1 DC characteristics and supply block

Without influence on the DC characteristics (except a slight difference at very low line current), the TEA1118/A can be used in two different supply configurations: they can provide supply to peripheral circuits like any IC from the TEA111x family of line interfaces or they can be externally supplied if an external power supply is available.

3.1.1 DC characteristics

Principle of operation

The ICs generate a stabilized voltage (called Vref) between pins LN and SLPE. This reference voltage, typically 3.35 V, is temperature compensated. The voltage at pin REG is used by the internal regulator to generate the stabilized Vref voltage and is decoupled by a capacitor Creg connected to VEE.

For effective operation of the apparatus, the TEA1118/A must have a low resistance to the DC current and a high impedance to speech signals. The Creg capacitor, converted into an equivalent inductance (see “set impedance” section), realizes this impedance conversion from its DC value (Rslpe) to its AC value (Rcc +Rz//Cz in the audio frequency range). The DC voltage at pin SLPE is proportional to the line current.

This general configuration is shown in fig. 6.

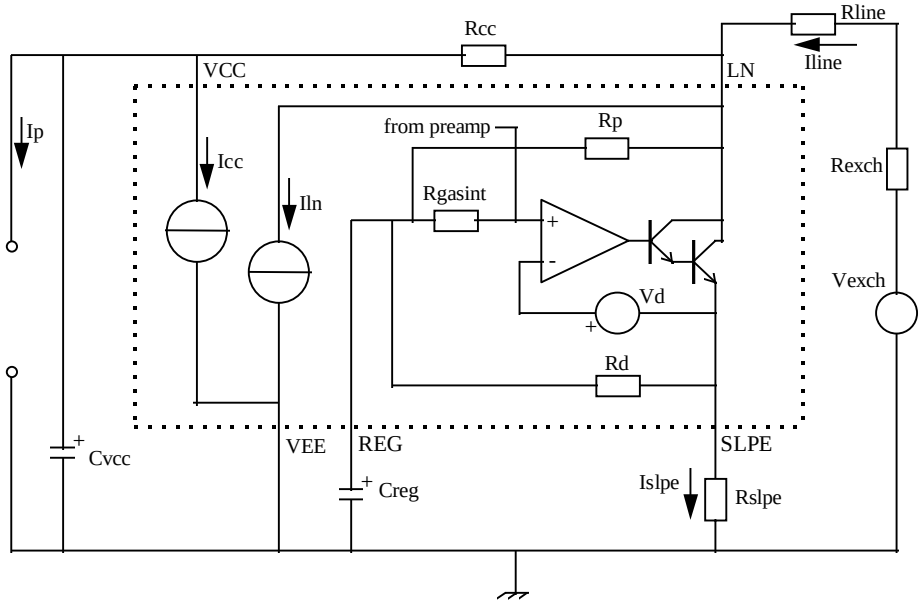

Fig. 6 DC characteristics configuration

The ICs regulate the line voltage between pins LN and SLPE. the voltage on pin LN can be calculated as:

$V_{ln} = V_{ref} + R_{slpe} \times I_{slpe}$

$I_{slpe} = I_{line} - I_{cc} - I_p - I_{ln}$

I_{line} = line current

I_{cc} = current consumption of the IC

I_p = supply current for peripherals

I_{ln} = Current consumption between LN and VEE

The DC line current Iline flowing into the apparatus is determined by the exchange supply voltage Vexch, the feeding bridge resistance Rexch, the DC resistance of the telephone line Rline and the voltage across the apparatus including diode bridge.

Below a threshold line current Ith (typically equal to 7.5 mA) the internal reference voltage (generating Vref) is automatically adjusted to a lower value (down to an absolute minimum voltage of 1.6 V). In this range, the shape of the curve giving Vref versus line current is slightly different if VCC is used to supply peripheral circuits or if the TEA1118/A are supplied from external supply. This means that more sets can operate in parallel or that for very low voltage feeding bridge the line current has a higher value. For line currents below this threshold current, the TEA1118/A has reduced sending and receiving performances. This is called the low voltage area.

The internal circuitry of the TEA1118/A is supplied from pin VCC. In line powered application, this voltage is derived from the line voltage by means of a resistor (Rcc) and must be decoupled by a capacitor (Cvcc). Fig. 7 shows the IC current consumption (Icc) as a function of the VCC supply voltage.

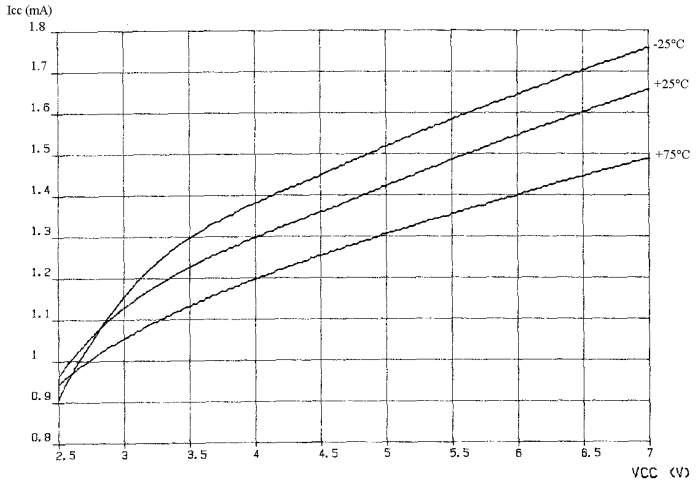

Fig. 7 Icc versus VCC

Fig. 8 shows the main voltages as a function of the line current.

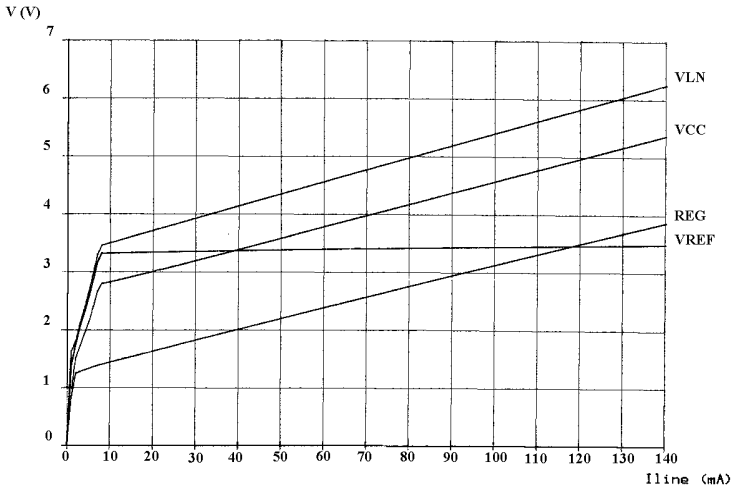

Fig. 8 Main voltages versus line current

Fig. 9 shows the behavior in the low voltage area in line powered condition while fig. 10 shows this behavior when the ICs are externally powered.

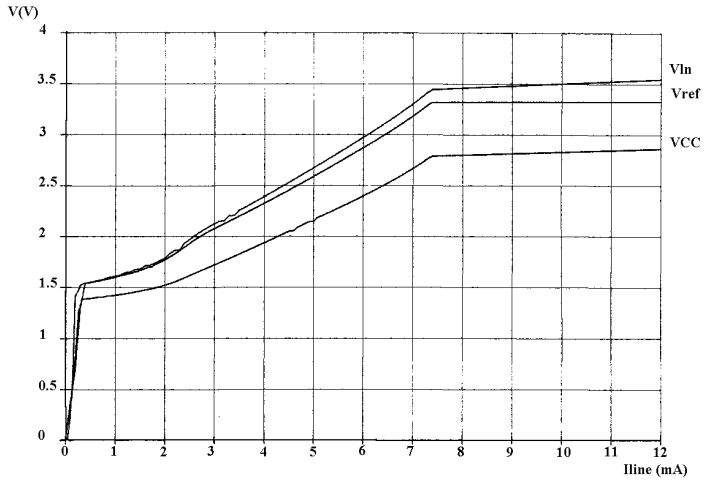

Fig. 9 Low voltage behavior in line powered conditions

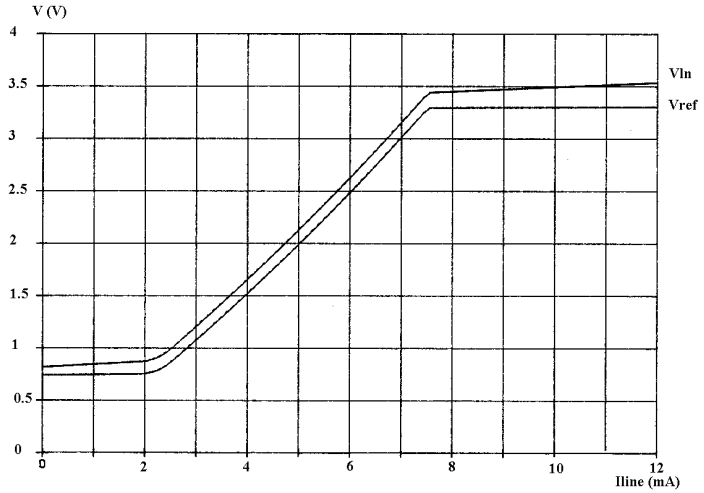

Fig. 10 Low voltage behavior with external 3.3 V power supply

Adjustments and performances

The reference voltage, Vref, can be adjusted by means of an external resistor Rva. It can be increased by connecting the Rva resistor between pins REG and SLPE (see fig; 11), or decreased by connecting the Rva resistor between pins REG and LN. In case of line powered application, it is not recommended to use the voltage reduction because it reduces the peripheral supply capability. To ensure correct operation, it is not advised to adjust Vref at a value lower than 3 V or higher than 7 V (the maximum operating voltage of 12 V must be guaranteed by the application). These adjustments will slightly affect a few parameters: there will be a small change in the temperature coefficient of Vref and a slight increase in the spread of this voltage reference due to matching between internal and external resistors. Furthermore, the Rva resistor connected between REG and LN will slightly affect the apparatus impedance(see section “set impedance”).

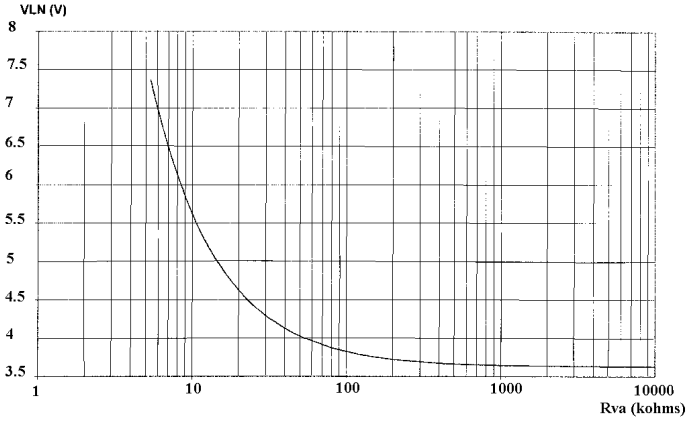

Fig. 11 Influence of an Rva resistor between REG and SLPE on Vln at 15mA

The DC slope of the voltage on pin LN is influenced by the Rslpe resistor as shown in fig. 12. The preferred value for Rslpe is 20 Ω, changing this value will affect more than the DC characteristics, it also influences the gains, the AGC characteristics, the maximum output swing on the line and the low voltage threshold Ith.

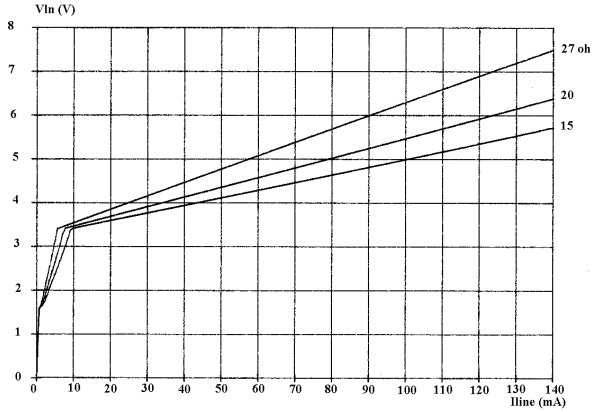

Fig. 12 Influence of Rslpe on the DC characteristics

3.1.2 Supply for peripherals

This sub-chapter concerns line powered applications which may not be usual for these ICs.

Principle of operation

The supply voltage at pin VCC is normally used to supply the internal circuitry of the TEA1118/A. However, a small current can be drawn to supply peripheral circuits having VEE as ground reference. The VCC supply voltage depends on the current consumed by the IC and the peripheral circuits as shown by the following formula:

$$VCC = VCC0 - Rccint \times (Iqr + Ip)$$

$$VCC0 = VLN - Rcc \times Icc$$

Iqr = internal current necessary to supply the receive output amplifier when there is AC signal

Rccint = Rcc // internal equivalent impedance between VCC and VEE

Rccint is the output impedance of the voltage supply point. As can be seen from fig. 7, the internal supply current Icc depends on the voltage on the pin VCC, it means that the impedance of the internal circuitry connected between VCC and VEE is not infinite. While supplying a peripheral circuit on VCC, the Ip supply current flowing through the Rcc resistor decreases the value of the voltage on the pin VCC and then reduces the Icc consumption. So, the impedance to use in combination with Ip and Iqr is not Rcc but Rccint which include in parallel the impedance of the internal circuitry connected between VCC and VEE. For a line current equal to 15 mA and Rcc equal to 620 Ω, this Rccint impedance is 550 Ω.

As VCC is limited to a minimum value to ensure correct operation, Ip will be limited to a maximum value.

Adjustments and performances

As the impedance connected between LN and VCC also determines the set impedance, the easiest way to increase the current capability of the supply point VCC is to increase the reference voltage Vref by connecting a resistor Rva between pins REG and SLPE (see 3.1.1).

3.2 Set impedance

Principle of operation

The ICs behave like an equivalent inductance that presents a low impedance to DC (Rslpe) and a high impedance (Rp) to speech signals. Rp is an integrated resistance in the order of 15.5 kΩ +/-15%. It is in parallel with the external RC realized by Rcc and Cvcc. Thus, in the audio frequency range, the apparatus impedance (called set impedance) is mainly determined by the Rcc resistor. Fig. 13 shows an equivalent schematic for the set impedance.

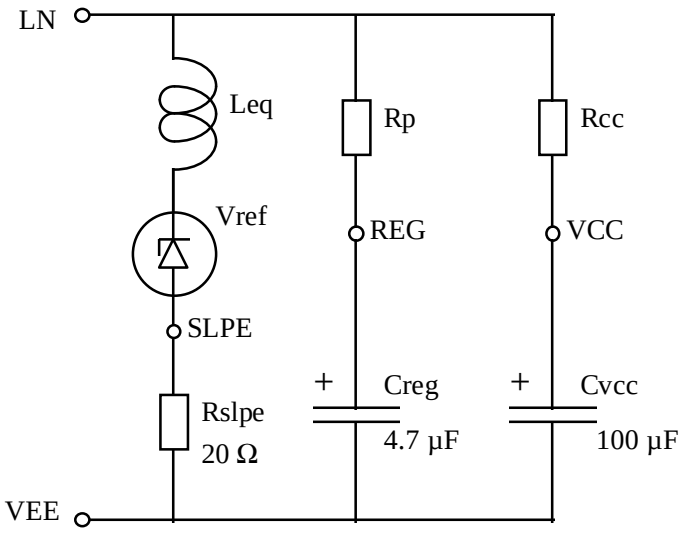

Fig. 13 Equivalent set impedance

Adjustments and performances

When decreasing the reference voltage Vref, a resistor is connected between LN and REG in parallel of Rp (see fig. 13) so, slightly modifying the impedance.

If complex set impedance is required, the Rcc resistor resistor is replaced by a complex network (see fig. 5 :Rcc + Rz // Cz). The DC resistance which influences the value of VCC becomes Rcc + Rz.

3.3 Transmit amplifier

Principle of operation

In fig. 14, the block diagram of the transmit amplifier of the TEA1118/A is depicted.

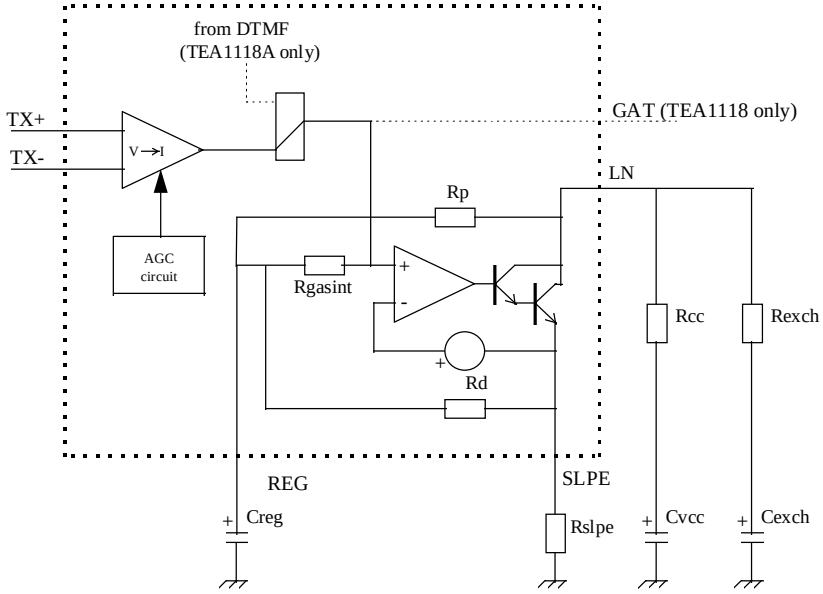

Fig. 14 Transmit channel

The transmit amplifier has symmetrical high input impedances (typically 64 kΩ -2 times 32 kΩ- between pins TX+ and TX- with maximum tolerances of +/- 15%). The input of this transmit amplifier is able to handle AC signals up 900 mVrms with less than 2% total harmonic distortion.

As can be seen from fig. 14, the transmit amplifier itself is built up out of two parts: a preamplifier which realizes a voltage to current conversion, and an end-amplifier which realizes the current to voltage conversion. The overall gain (Gvtx) of the transmit amplifier from inputs TX+/TX- to output LN is given by the following equation:

$$Gvtx = 20 \times \log Avtx$$

$$Avtx = 0.016 \times (Rgasint / Rrefint) \times (Ri//Zline / Rslpe) \times \alpha$$

with:

Ri = the AC apparatus impedance, Rcc//Rp (typically 620 Ω // 15.5 kΩ)

Rgasint = internal resistor realizing the current to voltage conversion (typically 27.6 kΩ with a spread of +/-15%)

Rrefint = internal resistor determining the current of an internal current stabilizer (typically 3.4 kΩ with a spread of +/- 15% correlated to the spread of Rgasint)

Zline = load impedance of the line during the measurement

α = gain control factor varying from 1 at Iline = 15 mA to 0.5 at Iline = 75 mA when AGC function is applied (see chapter 3.6 for details)

Using these typical values in the equation and assuming Zline = 600 Ω, we find a gain equal to:

$$Gvtx = 20 \times \log Avtx = 11\ dB \quad \text{at Iline} = 15\ mA$$

The different gain controls (AGC; MUTE and TMUTE for TEA1118A only) act on the transmit preamplifier stage, modifying its transconductance.

Adjustments and performances

On the **TEA1118 only**, the transmit gain can be decreased by connecting a resistor Rgat between pins GAT and REG. It can be adjusted from 11 dB to 5 dB to suit application specific requirements, however, this gain adjustment slightly increases the gain spread and affects the temperature coefficient due to matching between internal and external resistors. Fig. 15 shows the typicall curve of the transmit gain versus the external resistor Rgat. The gain dependancy to this external Rgat resistor is given by the following equation:

$$Gvtx = 20 \times \log [\ 0.016 \times (Rgasint//Rgat\ /\ Rrefint) \times (Ri//Zline\ /\ Rslpe) \times \alpha\ ]$$

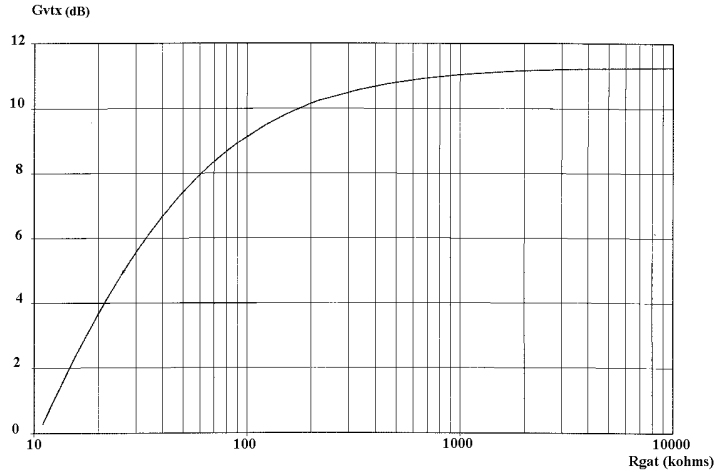

Fig. 15 Transmit gain versus Rgat connected between GAT and REG

A capacitor Cgat can be connected between pins GAT and REG of the TEA1118 to provide a first order low-pass filter which cut-off frequency is determined by the product Cgat × (Rgasint//Rgat). Fig 16 shows the typical frequency response of the transmit amplifier (without filter) of the TEA1118/A.

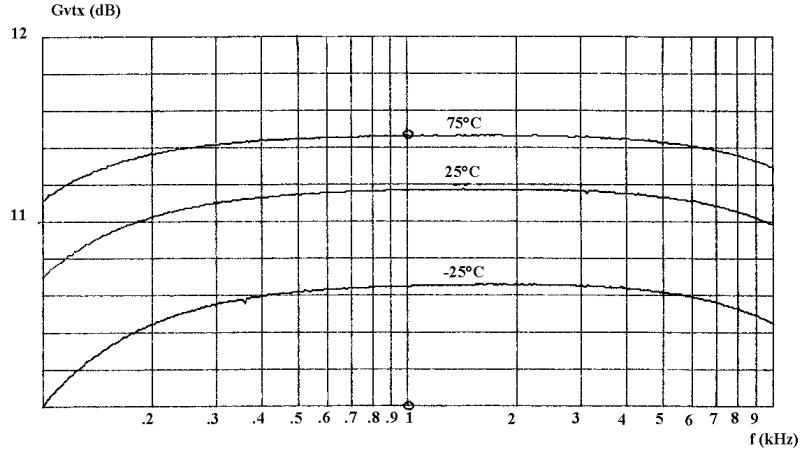

Fig. 16 Transmit gain versus frequency: influence of temperature

Fig 17 shows the distortion of the signal on the line as a function of the transmit signal at nominal DC settings and for a line current of 15 mA for TEA1118/A, while fig. 18 shows this distortion versus the input transmit signal when the transmit gain is reduced to 5 dB on the TEA1118.

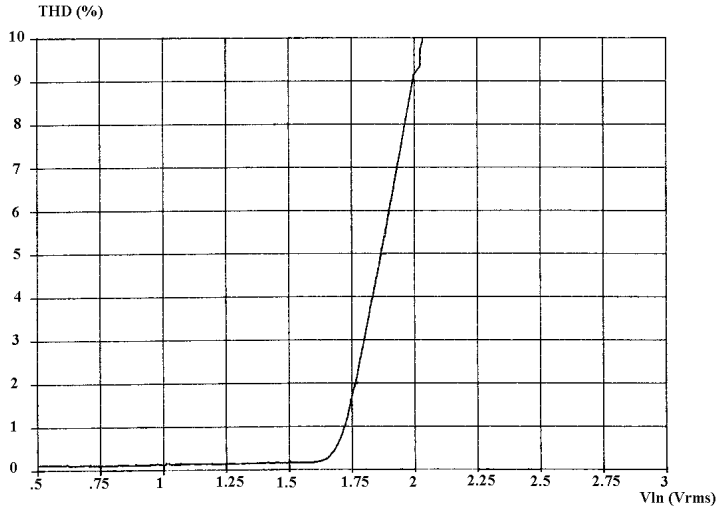

Fig. 17 Distortion on line versus transmit signal at nominal gain on TEA1118/A

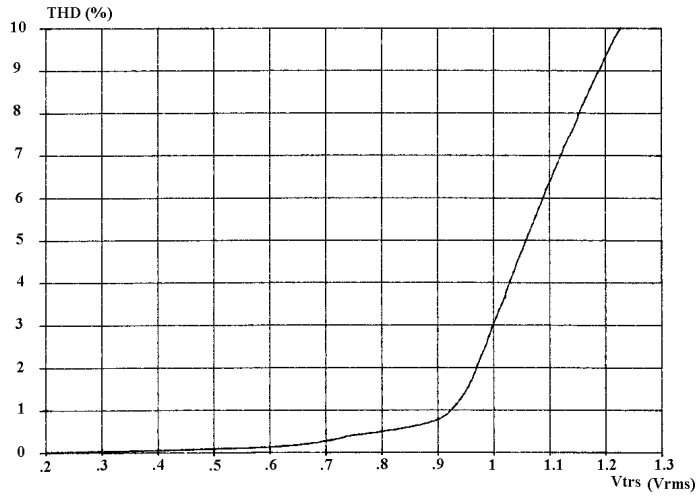

Fig. 18 Distortion on the line versus transmit signal at 5 dB gain on TEA1118

Fig. 19 shows the distortion of the line signal versus the input transmit signal on the line at line current of 4 mA and nominal gain when the TEA1118/A are powered from an external 3.3 V power supply between VCC and VEE.

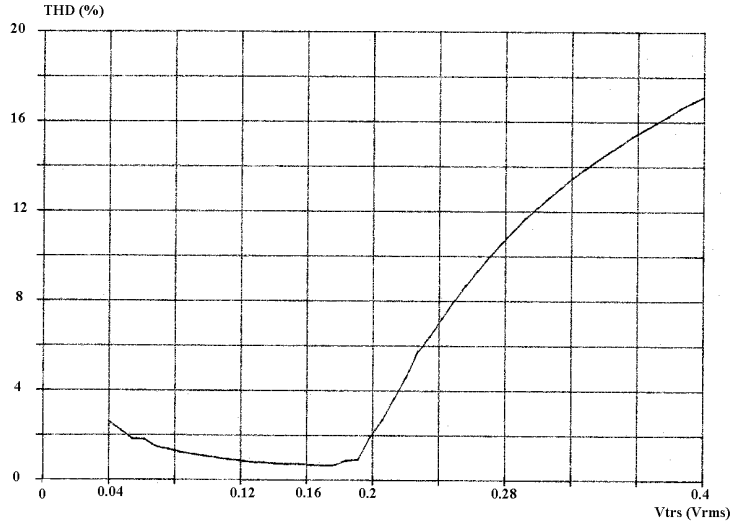

Fig. 19 Distortion of line signal at Iline = 4 mA with external 3.3 V power supply

Fig. 20 shows the transmit noise (psophometrically weighted: P53 curve) versus line current at nominal gain when a 200 Ω resistor is connected between the inputs TX+ and TX-.

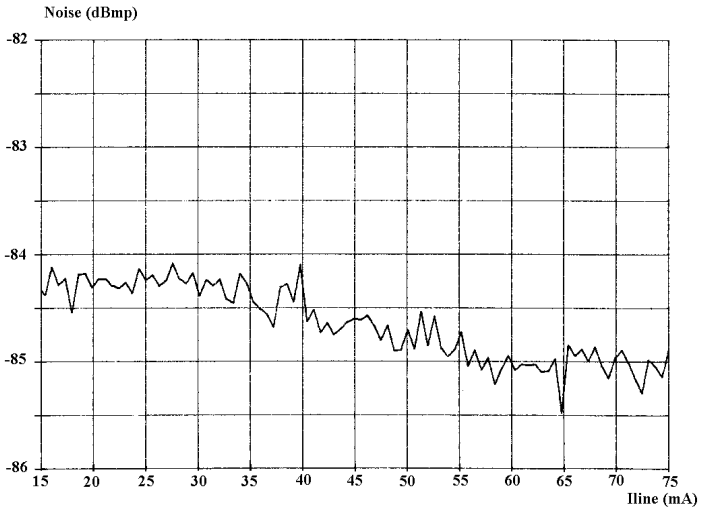

Fig. 20 Transmit noise versus line current

Fig. 21 shows the common mode rejection ratio at 15 mA and at nominal transmit gain. Two curves are present in this fig. 21, the first one is the spectrum of the signal on pin LN when a transmit signal is applied on pin TX- while pin TX+ is shorted to VEE, the second one is the spectrum of the signal on pin LN when a transmit signal is applied on pins TX- and TX+ shorted together. Both signals are at 1 kHz, the difference between the two curves gives the CMRR.

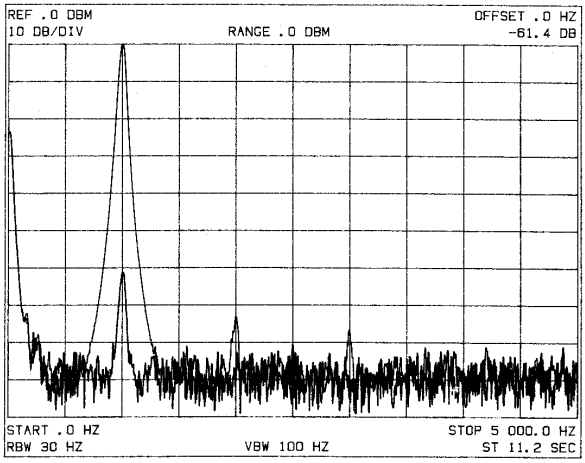

Fig. 21 Common mode rejection ratio on transmit

3.4 TMUTE function (TEA1118A only)

Principle of operation

The transmit mute function realizes an electronic switching between the transmit amplifier and the sending DTMF amplifier. This function disables the transmit channel to provide a kind of privacy function and at the same time enables the DTMF channel if needed for some specific applications; this function has no effect on the receive channel. If a high level is applied to the TMUTE input, the transmit channel is disabled while the DTMF channel is enabled, by applying a low level or leaving pin TMUTE open (if MUTE pin level is low) the transmit channel is enabled. The threshold voltage level is 0.68 V typically with a temperature coefficient of -2 mV/°C. Fig. 22 shows the transmit gain reduction and TMUTE input current versus TMUTE input voltage.

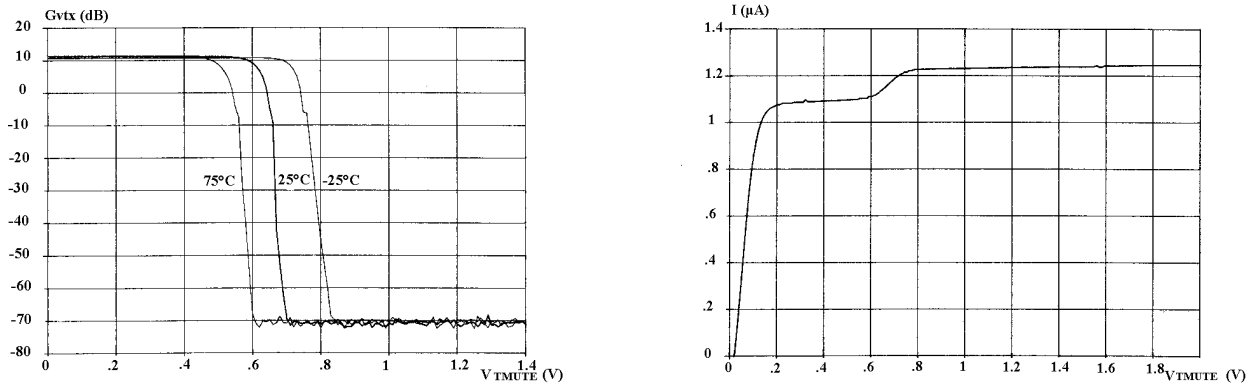

Fig. 22 Transmit gain and TMUTE input current versus TMUTE input voltage

Adjustment and performances

Fig. 23 shows the transmit amplifier gain reduction at Iline = 15 mA for an input signal of 1 kHz. Two curves are present on this fig. 23, the first one shows the spectrum of the signal on the line when a signal is applied on the transmit inputs and when TMUTE is at a low level, the second one shows the same signal when pin TMUTE is at a high level. The difference between the two curves at this frequency gives the gain reduction.

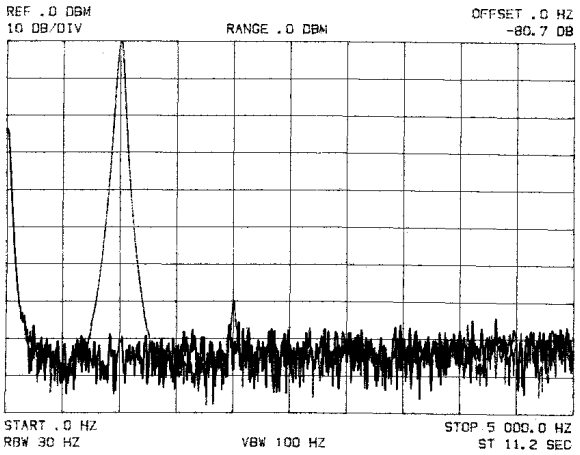

Fig. 23 Transmit gain reduction in TMUTE condition

The TMUTE function works down to a voltage on VCC equal to 1.6 V, below this threshold, the transmit amplifier stays always enabled independently of the TMUTE input level. The maximum voltage allowed at pin TMUTE is VCC +0.4 V.

3.5 Receive amplifier

Principle of operation

In fig. 24, the block diagram of the receive amplifier is depicted.

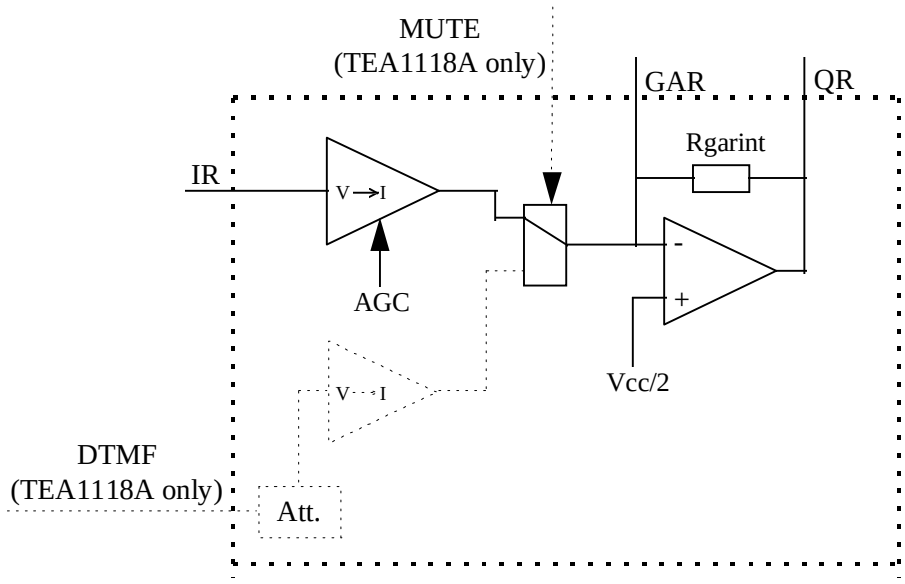

Fig. 24 Receive channel

The receive amplifier has an a-symmetrical high input impedance between pins IR and VEE. It is equal to 20 kΩ with a maximum tolerance of +/-15%. The ICs are able to drive loads down to an impedance of 150 Ω. As can be seen from fig. 24, the receive amplifier itself is built up out of two parts: a preamplifier which realizes a voltage to current conversion and an end-amplifier which realizes the current to voltage conversion. The overall gain Gvrx of the receive amplifier from input IR to output QR is given by the equation:

$$Gvrx = 20 \times \log Avrx$$

$$Avrx = \alpha \times 1.21 \times Rgarint/Rrefint$$

with:

Rgarint = internal resistor realizing the current to voltage conversion (typically 100 kΩ with a spread of +/-15%)

Rrefint = internal resistor determining the current of an internal current stabilizer (typically 3.4 kΩ with a spread of +/- 15% correlated to the spread of Rgasint)

α = gain control factor varying from 1 at Iline = 15 mA to 0.5 at Iline = 75 mA when AGC function is applied (see chapter 3.6 for details)

Using these typical values in the equation, we find a gain equal to:

$$Gvrx = 20 \times \log Avrx = 31 \text{ dB} \quad \text{at Iline} = 15 \text{ mA}$$

The different gain controls (AGC; MUTE for TEA1118A only) act on the receive preamplifier stage, modifying its transconductance.

Adjustments and performances

The receive gain can be decreased on the TEA1118/A by connecting a resistor Rgar between pins GAR and QR. It can be decreased from 31 dB down to 19 dB to suit application specific requirements, however, this gain adjustment slightly increases the gain spread and affects the temperature coefficient due to matching between internal and external resistors. 31 dB of receive gain compensate almost typically the attenuation provided by the antisidetone network. Fig. 25 shows the typicall curve of the receive gain versus the external resistor Rgar. The gain dependancy to this external Rgar resistor is given by the following equation:

$$Gvrx = 20 \times \log [\ 1.21 \times (Rgarint//Rgar\ /\ Rrefint) \times \alpha\ ]$$

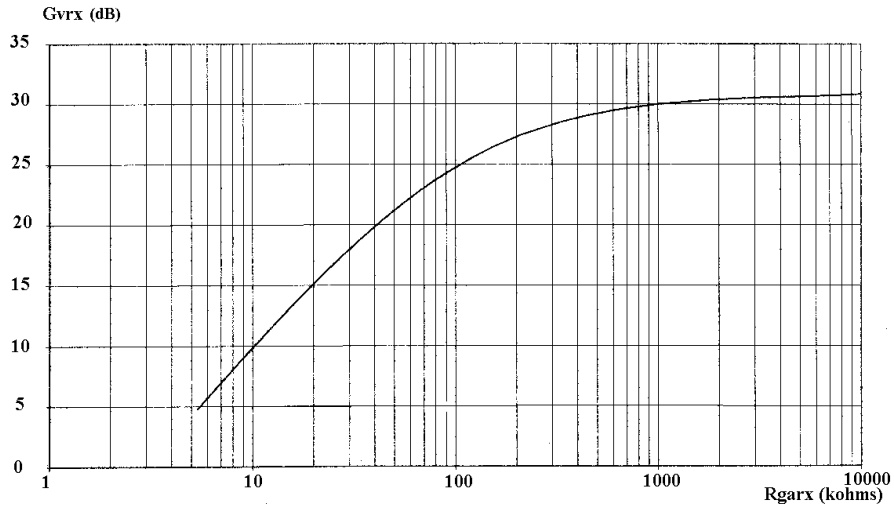

Fig. 25 Receive gain versus Rgar connected between GAR and QR

Two external capacitors Cgar (connected between GAR and QR) and Cgars (connected between GAR and VEE) ensure stability when the relationship Cgars ≥ 10 × Cgar is fulfilled. The Cgar capacitor provides a first order low pass filter, which cut-off frequency is determined with Rgarint//Rgar. Fig. 26 shows the frequency response of the receive amplifier at different temperatures (Cgar = 100 pF, Cgars = 1 nF).

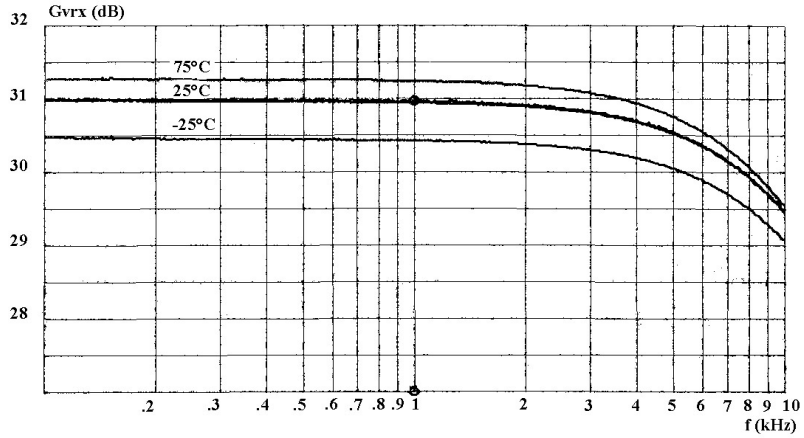

Fig. 26 Receive gain versus frequency and temperature

The maximum output swing on QR depends on the DC line voltage, the Rcc resistor, the Icc current consumption of the circuit, the Ip current consumption of the peripheral circuits and the load impedance on QR. The receiving input IR can handle signals up to 18 mVrms with less than 2% THD. Fig. 27 shows the distortion on QR when the limitation is related to the input voltage for a line current equal to 75 mA. Fig. 28 shows the distortion of the signal on QR as a function of the rms signal on QR with a load of 450 Ω and a line current of 15 mA.

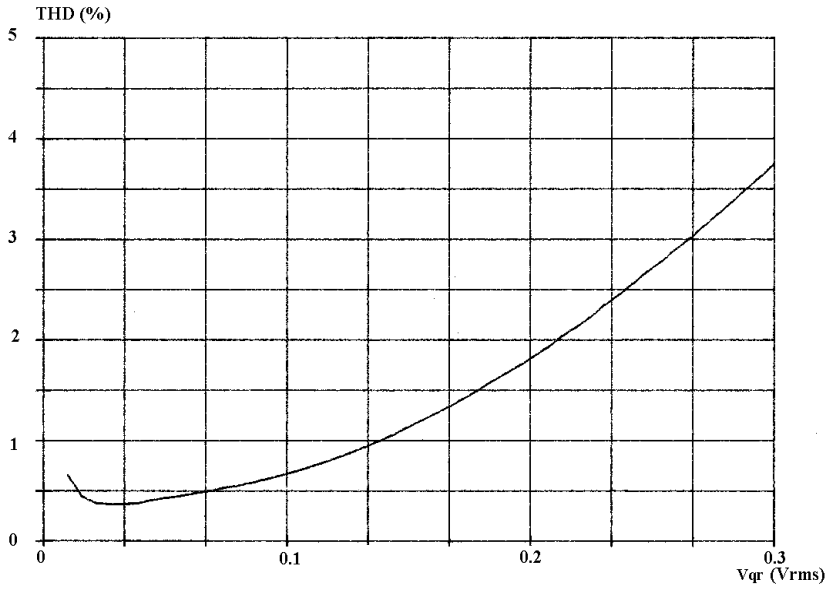

Fig. 27 Distortion on QR versus input signal on IR

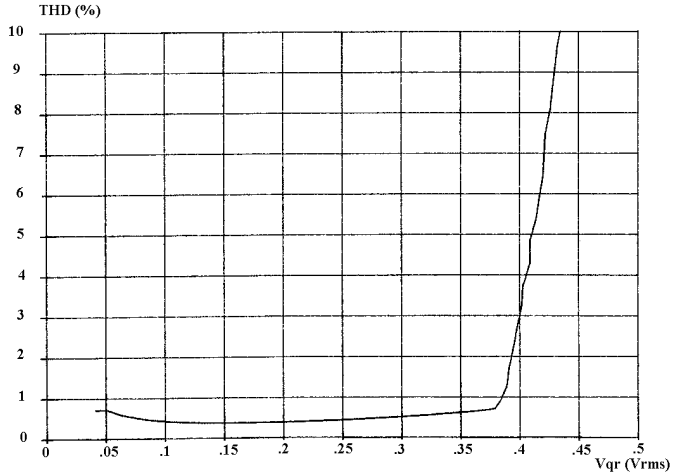

Fig. 28 Distortion on QR versus level with 450 Ω load

Fig. 29 shows the noise on QR loaded with 150 Ω (psophometrically weighted: P53 curve) as a function of the line current. This curve has been done with an open input IR. With the antisidetone network connected to the input IR, part of the transmit noise generated on the line will be added but, thanks to the low transmit noise value, the effect is negligible.

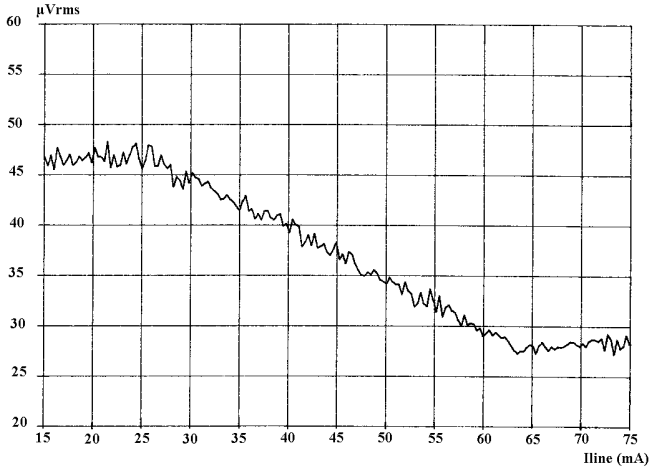

Fig. 29 Noise on QR

3.6 Automatic gain control

Principle of operation

The TEA1118/A perform automatic line loss compensation. The automatic gain control varies the gain of the transmit and receive amplifiers in accordance with the DC line current. To enable this AGC function, the pin AGC must be connected to the pin VEE. For line currents below a current threshold, Istart (typically 25 mA), the gain control factor α is equal to 1, giving the maximum value to the gains Gvtx and Gvrx. If this threshold

current is exceeded, the gain control factor α is reduced and then the gains of the controlled transmit and receive amplifiers are also reduced. When the line current reaches an other threshold current, Istop (typically 63 mA), the gain control factor α is limited to its minimum value equal to 0.5, giving the lower value to the transmit and receive controlled gains. The gain control range of both amplifiers is typically 5.8 dB, which corresponds to a line length of 5 km (0.5 mm twisted pair copper) with an attenuation of 1.2 dB/km.

The attenuation is correlated to the current Iagc sunk at pin AGC: when this current is lower than typically 5 µA the gains are maximum, when this current is higher than typically 13 µA the gains are minimum. This current is proportional to the voltage between pins SLPE and VEE. There is an internal resistor which sets Istart and Istop, adding one externally in series (between pins AGC and VEE) reduces Iagc and increases the values of Istart and Istop.

Adjustments and performances

The ICs are optimized for use with an exchange supply voltage of 48 V, a feeding bridge of $2 \times 300\ \Omega$ and the line previously described. In order to fit with other configurations, a resistor Ragc, can be inserted between pins AGC and VEE. This Ragc resistor increases the two threshold currents Istart and Istop. Fig. 30 shows the control of the transmit gain versus the line current for different values of Ragc. When no AGC function is required, the AGC pin must be left open, then the control factor α equals to 1 and both controlled gains are at their maximum values.

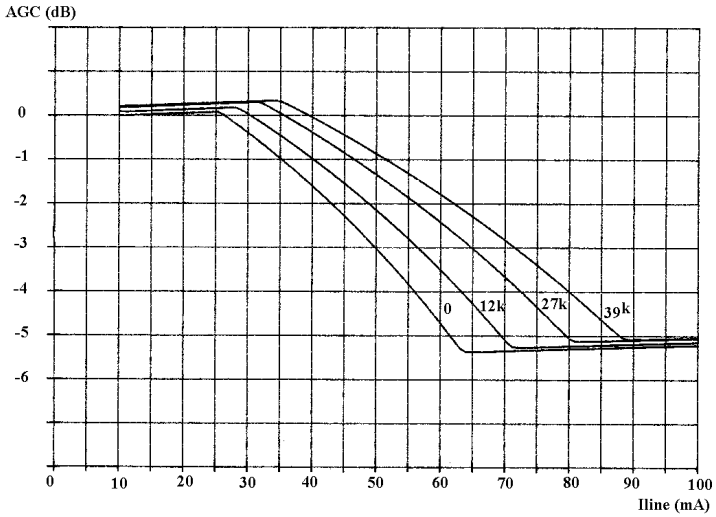

Fig. 30 AGC on the transmit gain versus line current and Ragc

3.7 DTMF amplifier (TEA1118A only)

principle of operation

In fig. 31, the block diagram of the DTMF channel of the TEA1118A is depicted.

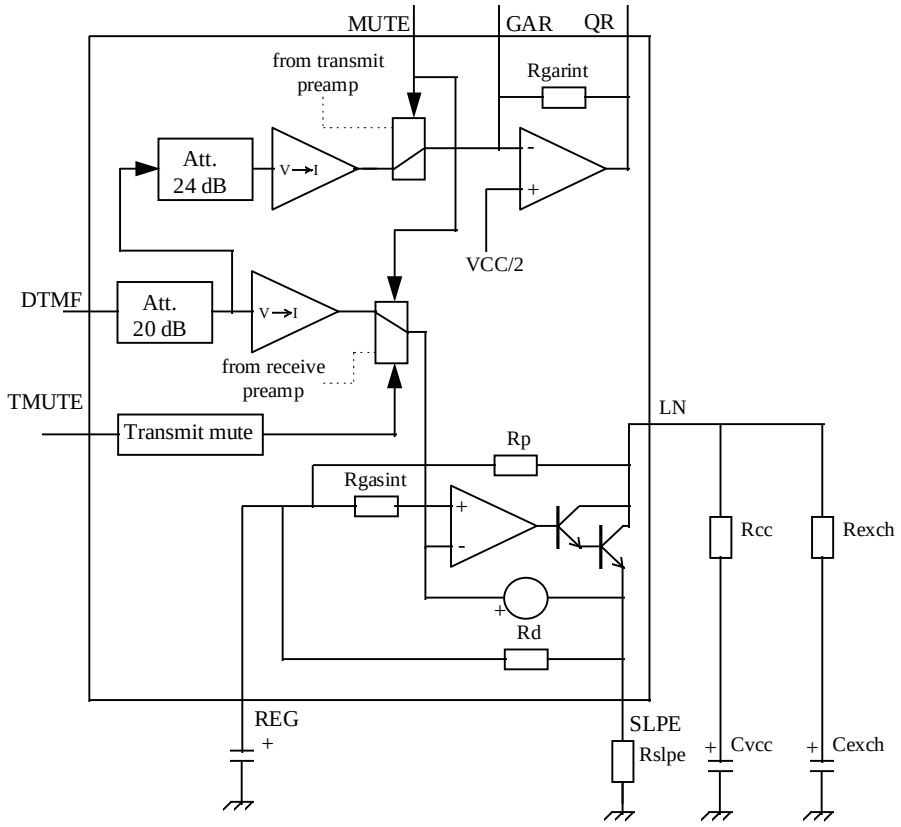

Fig. 31 DTMF channel of the TEA1118A

The DTMF amplifier has an a-symmetrical high input impedance of 20 kΩ between pins DTMF and VEE with a maximum spread of +/-15%. The DTMF amplifier is built up out of three parts: an attenuator by a factor of 10, a preamplifier which realizes the voltage to current conversion and the same end-amplifier as the transmit amplifier. No AGC is applied to the DTMF channel. The overall gain (Gvmf) of the DTMF amplifier from input DTMF to output LN is given by the following equation:

$$Gvmf = 20 \times \log Avmf$$

$$Avmf = 0.032 \times (Rgasint / Rrefint) \times (Ri//Zline / Rslpe)$$

with:

Ri = the AC apparatus impedance, Rcc//Rp (typically 620 Ω // 15.5 kΩ)

Rgasint = internal resistor realizing the current to voltage conversion (typically 27.6 kΩ with a spread of +/-15%)

Rrefint = internal resistor determining the current of an internal current stabilizer (typically 3.4 kΩ with a spread of +/- 15% correlated to the spread of Rgasint)

Zline = load impedance of the line during the measurement

Using these typical values in the equation and assuming Zline = 600 Ω, we find a gain equal to:

$$Gvmf = 20 \times \log Avmf = 17.4 \text{ dB}$$

Fig. 32 shows the frequency response of the DTMF amplifier at 15 mA and different temperatures.

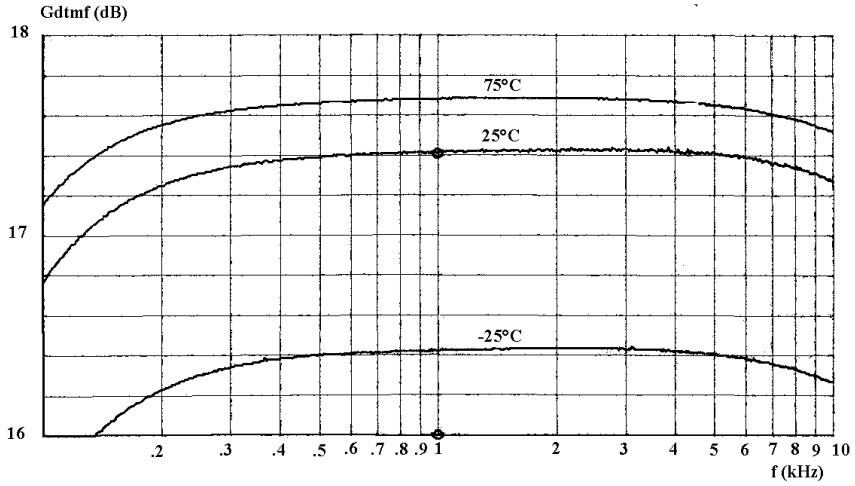

Fig. 32 DTMF gain versus frequency at different temperatures

The input of the DTMF amplifier can handle signals up to 180 mVrms with less than 2% THD. Fig. 33 shows the distortion on line versus the rms input signal at Iline = 15 mA.

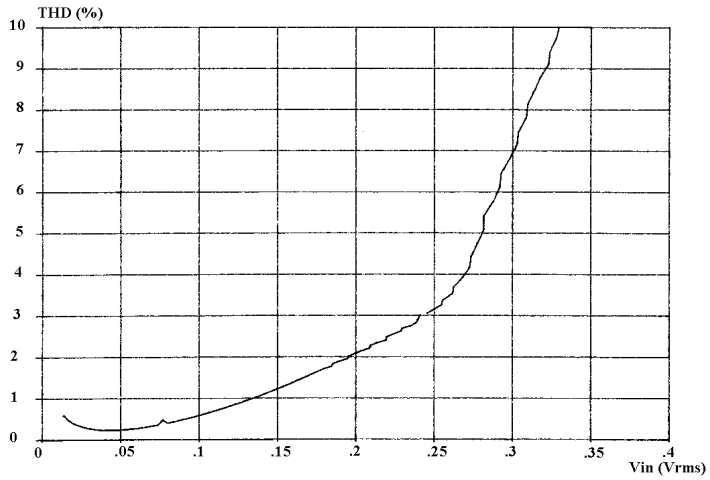

Fig. 33 Distortion of the DTMF signal on line versus input signal

3.8 MUTE function (TEA1118A only)

Principle of operation

The mute realizes an electronic switching between the speech mode and the dialling mode. If a high level is applied to the MUTE input, both the transmit and the receive channels are disabled while the DTMF channel is enabled. By applying a low level or leaving pin MUTE open the receive channel is enabled moreover, if TMUTE pin level is low, the transmit channel is also enabled. The threshold voltage level is 0.68 V typically with a

temperature coefficient of -2 mV/°C. Fig. 34 shows the transmit gain reduction and MUTE input current versus MUTE input voltage.

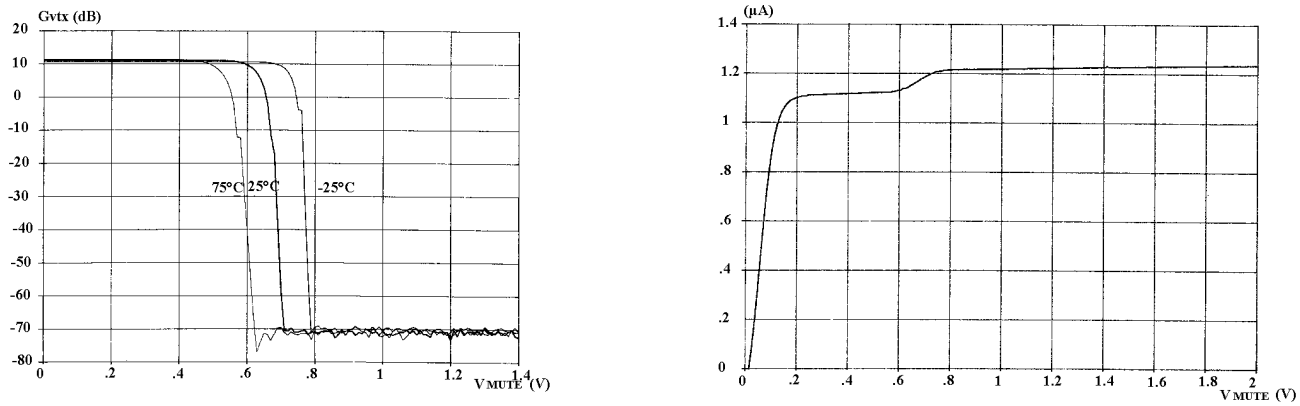

Fig. 34 Transmit gain and MUTE input current versus MUTE input voltage

Adjustments and performances

Fig. 35 shows the transmit and receive amplifier gain reduction at Iline = 15 mA for an input signal of 1 kHz. Two curves are present on these graphics, the first one shows the spectrum of the signal on the line (or on QR) when a signal is applied on the transmit inputs (or respectively on IR) and when MUTE is at a low level, the second one shows the same signal when pin MUTE is at a high level. The difference between the two curves at this frequency gives the gain reduction.

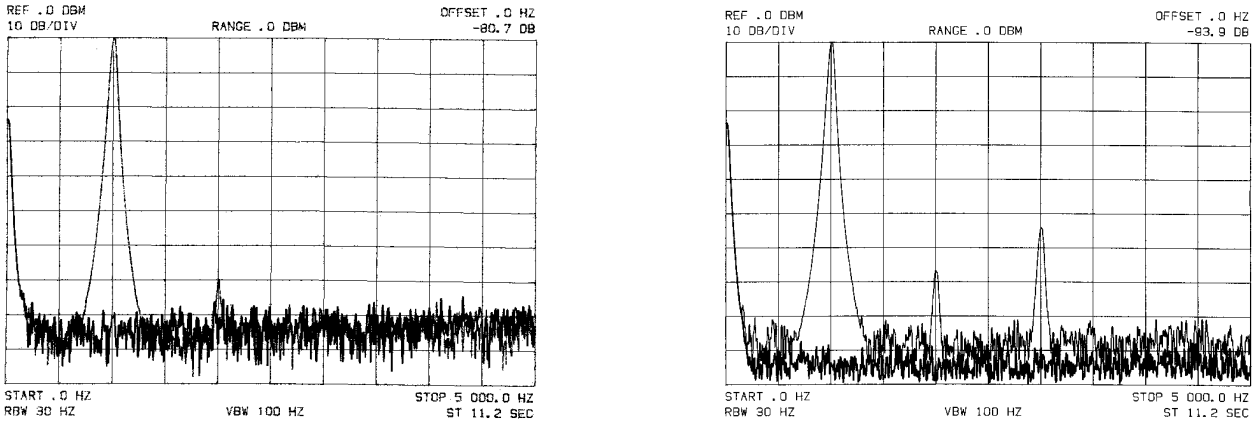

Fig. 35 Transmit and receive gain reduction in MUTE condition on the TEA1118A

The MUTE function works down to a voltage on VCC equal to 1.6 V, below this threshold, the transmit and receive amplifiers stays always enabled independently of the MUTE input level. The maximum voltage allowed at the MUTE input is VCC + 0.4 V.

3.9 Anti-sidetone network

Principle of operation

To avoid the transmit signal to come back with a too high level in the receive channel, the anti-sidetone circuit uses the transmit signal from pin SLPE (which is in opposite phase) to cancel the transmit signal at the IR input of the receive amplifier. The anti-sidetone bridge already used for the TEA106x or the TEA111x families or a conventional Wheatstone bridge as shown in fig. 36 may be used for the design of the anti-sidetone network.

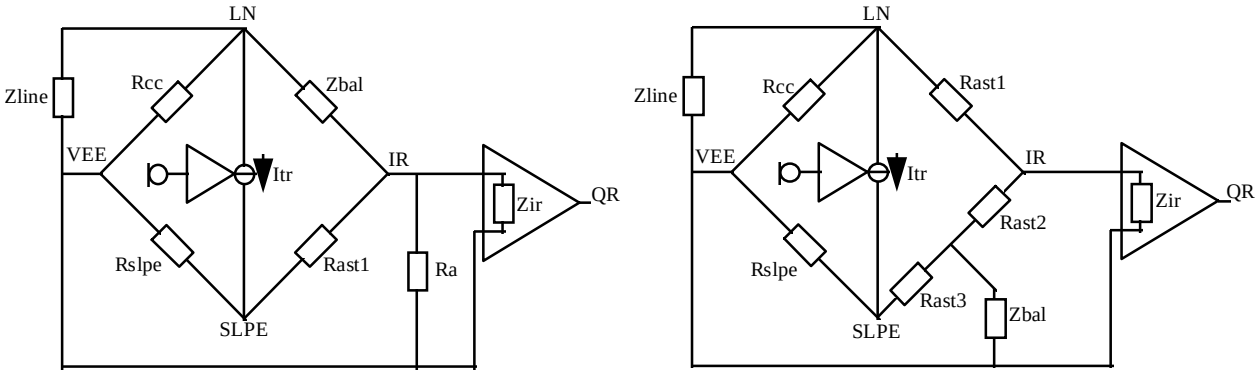

Fig. 36 Wheatstone bridge (left) and TEA106x orTEA111x family anti-sidetone bridge (right)

The TEA106x or TEA111x family anti-sidetone bridge has the advantage of a relative flat transfer function in the audio frequency range between the input IR and the output QR, both with real and complex set impedances. Furthermore, the attenuation of the bridge for the receive signal (between pins LN and IR) is independent of the value chosen for Zbal after the set impedance has been fixed and the condition shown in equation (6) is fulfilled. Therefore, readjustment of the overall receive gain is not necessary in many cases.

Compare to the previous one the Wheatstone bridge has the advantages of needing one resistor less and a smaller capacitor in Zbal. But the disadvantages include the dependence of the attenuation of the bridge on the value chosen for Zbal and the frequency dependence of that attenuation. This requires some readjustment of the overall receive gain.

3.9.1 TEA106x or TEA111x family bridge

The anti-sidetone circuit is composed of: Rcc//Zline, Rast1, Rast2, Rast3, Rslpe and Zbal. Maximum compensation is obtained when the following conditions are fulfilled:

$$Rslpe \times Rast1 = Rcc \times (Rast2 + Rast3) \quad (6)$$

$$k = [Rast2 \times (Rast3 + Rslpe)] / (Rast1 \times Rslpe)$$

$$Zbal = k \times Zline$$

The scale factor k is chosen to meet the compatibility with a standard value of capacitor for Zbal.

In practice, Zline varies strongly with line lenght and line type. Consequently, the value for Zbal has to be chosen to fit with an average line length giving acceptable sidetone suppression with short and long lines. The suppression further depends on the accuracy with which Zbal equals this average line impedance.

Example

Let’s optimize for a theorical equivalent average line impedance shown in Fig. 37.

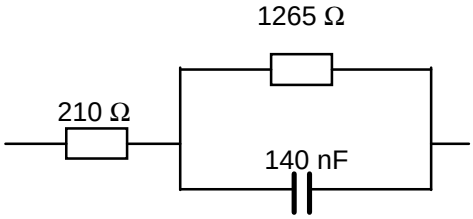

Fig. 37 Equivalent average line impedance

For compatibility of the capacitor value in Zbal with a standard capacitor value from the E6 series (220 nF):

k = 140 / 220 = 0.636

For Rast2, a value of 3.92 kΩ has been chosen. So, using the previous equations, we can calculate Zbal, Rast1, Rast3. We find Rast1 = 130 kΩ, Rast3 = 390 Ω, and for Zbal 130 Ω in series with 220 nF // 820 Ω.

The attenuation of the receive line signal between LN and IR can be derivated from the following equation:

Vir / Vln = (Zir // Rast2) / [Rast1 + (Zir // Rast2)]

If Rast2 >> (Rast3 // Zbal).

With the values used in this example, it gives 32 dB at 1 kHz.

Zir is the receive amplifier input impedance, typically 20 kΩ.

3.9.2 Wheatstone bridge

The conditions for optimum suppression are given by:

Zbal = (Rast1 / Rslpe) × (Rcc // Zline)

Also, for this bridge type, a value for Zbal has to be chosen that corresponds with an average line length.

The attenuation of the received line signal between LN and IR is given by:

Vir / Vln = (Zir // Rast1 // Ra) / [Zbal + (Zir // Rast1 // Ra)]

Ra is used to adjust the bridge attenuation; its value has no influence on the balance of the bridge.

4. APPLICATION COOKBOOK

In this chapter, the procedure for making a basic application is given. Reffering to fig. 38, the design flow is given as a number of steps which should be made. As far as possible for every step, the components involved and their influence on every step are given.

Step	Adjustment
DC setting :	
Adjust the DC setting of the TEA1118/A to the local PTT requirements.	
Voltage LN-VEE	This voltage can be adjusted by changing Vref: increased up to 7 V with a resistor between pins REG and SLPE or decreased down to 3 V with a resistor between REG and LN.
DC slope	The DC slope might be modified by changing the value of Rslpe (this is not advised: all gains are modified, AGC characteristic is modified).
Supply point VCC	In line powered applications, depends on the values of Vref and the resistive part of the impedance network (Rcc + Rz). External power supply can be applied.
Artificial inductor	Its value can be adjusted by changing the value of Creg: a smaller value speeds-up the DC current shape during transients but decreases the value of the inductance and then affects the BRL.
Impedance and sidetone :	
After setting the required set impedance, the sidetone has to be optimized using the sidetone network in order to minimize the loop gain in all line conditions. AGC can be adjusted at that step.	
Application impedance	The BRL is adjusted with the impedance network connected between LN and VCC (Rcc + Rz//Cz).
Sidetone	Adjust Zbal (Rbal1, Rbal2, Cbal) according to the line characteristics.
AGC	Internally defined, the characteristics (Istart and Istop) can be shiftted to higher line currents with an external Ragc resistor connected between AGC and VEE.

Step	Adjustment
TEA1118/A transmit and receive gains	
Transmit gain	The transmit gain of the application has to be adjusted preferably before entering pins TX+/TX- for the TEA1118/A. For the TEA1118 only, it is also possible to reduce the transmit gain with the resistor Rgat. Ctx1, Ctx2 and TX+/TX- input impedance form a high-pass filter. A capacitor Cgat in parallel with the transmit gain resistor (between TEA1118 pins REG and GAT) form a low-pass filter.
Receive gain	The receive gain of the application has to be adjusted preferably after the output QR, nevertheless, it is possible to reduce the receive gain with the resistor Rgar. A capacitor in parallel with the receive gain resistor (between TEA1118/A pins QR and GAR) form a low-pass filter, stability is ensured with capacitor Cgars (>10 $\times$ Cgar) between pins GAR and VEE.
TEA1118A only DTMF gain	
DTMF	The DTMF level on line must be adjusted before entering pin DTMF. It is selected with a high level either on pin TMUTE or on pin MUTE.

5. EXAMPLE OF APPLICATION

A demo board (OM4789) is available, as the TEA1118/A may be used in various applications, this demo board includes only the TEA1118A with its basic environment. Replacing the TEA1118A by a TEA1118 may make it usable also for the evaluation of the TEA1118 which offers the possibility to reduce the transmit gain.

Fig. 38 gives the basic application of the TEA1118/A. On this schematic, the capacitors connected with doted lines and the resistors drawn with dotted lines are indicated for RFI immunity purpose.

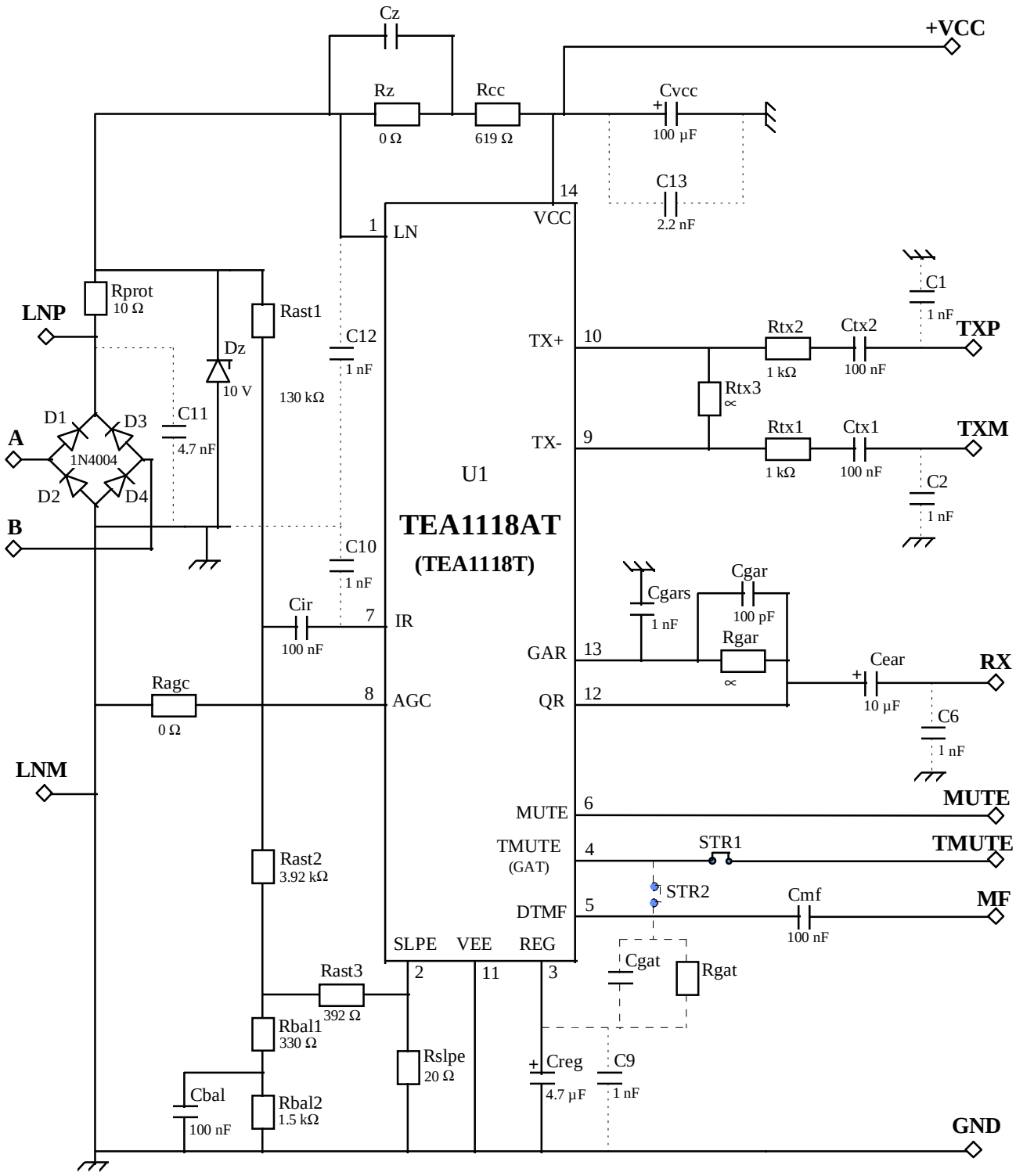

Fig. 38 Basic application of the TEA1118A

6. ELECTROMAGNETIC COMPATIBILITY

As no common international specification exists for RFI immunity, and as different assembly methods may lead to different solutions, only some advices can be provided.

It is advisable to take care of the impedance of the GND, the smallest is always the best. This means that the GND (VEE) trace must always be as large as possible, the best is to have a second layer dedicated to this purpose.

TX+/TX- inputs may also be sensitive (RF signals entering these pins would be amplified). Care has to be taken with the lay-out of the transmit amplifier, which is also helpfull for the noise, providing a good decoupling to GND. A low-pass RC filter may be added at the input of the amplifier.

Low impedance capacitors in parallel with the electrolythic one between VCC and GND as well as in parallel with the Creg capacitor may help.

Usually a low impedance capacitor connected between LN and GND helps for the conducted interferences, but this capacitor is in parallel with the impedance network of the apparatus, so, its value must be small enough.

In general when connections are coming from external environment (e.g. TXP, TXM, A, B on the demoboard), it is better to filter the RFI signal before it influences the close environment of the TEA1118/A (e.g. action of C1,C2,C11 on the demoboard).

7. REFERENCES

[1] TEA1118/A Versatile cordless transmission circuit
Device specification

[2] TEA1118/A Line Interface Demonstration Board
USER MANUAL of OM4789 (report n°: CTT96001)

[3] Philips Semiconductors
SEMICONDUCTORS FOR TELECOM SYSTEMS -IC03-

APPENDIX LIST OF ABBREVIATIONS AND DEFINITIONS

A-B	Line terminals of application example
AGC	Automatic Gain Control: line loss compensation
BRL	Balance Return Loss: matching between the apparatus impedance and a reference
DTMF	Dual Tone Multi Frequency
EMC	ElectroMagnetic Compatibility
GAR	Receive gain adjustment pin of the TEA1118/A
GAT	Transmit gain adjustment pin of the TEA1118
GND	Ground
Gvmf	DTMF amplifier gain
Gvrx	Receive gain
Gvtx	Transmit gain
IC	Integrated circuit
Icc	Current consumption of the TEA1118/A
Iline	Line current
Ip	Current consumption of the peripherals
Iqr	Internal current consumption (fromVCC) of the receive amplifier
IR	Receive amplifier input pin of the TEA1118/A
Islpe	Part of the line current flowing through SLPE pin
Istart	Start current of the AGC function
Istop	Stop current of the AGC function
Ith	Threshold current of the low voltage part
k	Scale factor of anti-sidetone network
Leq	Artificial inductor of the voltage stabilizer
MUTE	MUTE input of the TEA1118A
TMUTE	TMUTE input of the TEA1118A (transmit channel)
OM4789	Demoboard of the TEA1118A
QR	Receive amplifier output pin of the TEA1118/A
Ra	Resistor to adjust the sidetone bridge attenuation
Rast	Antisidetone resistor
REG	Filter capacitor of the equivalent inductor connection pin of the TEA1118/A
Rexch	Bridge resistance of exchange
RFI	Radio Frequency Interference

Rgar	External resistance to reduce receive gain of TEA1118/A
Rgarint	Internal resistance (100 kΩ) which sets the receive gain
Rgasint	Internal resistance (27 kΩ) which sets the transmit gain
Rgat	External resistance to reduce transmit gain of TEA1118
Rp	Internal resistance between LN and REG
SLPE	Slope input pin of the TEA1118/A
THD	Total Harmonic Distortion (%)
TX+/TX-	Transmit amplifier input pins of the TEA1118/A
VCC	Positive supply of the TEA1118/A
VEE	Ground reference of the TEA1118/A
Vln	DC voltage between LN and VEE
Vref	Stabilized reference voltage between LN and SLPE
Vslpe	DC voltage level between SLPE and VEE
Zir	Input impedance of the receive amplifier of the TEA1118/A
Zbal	Anti-sidetone network
α	Gain control factor of the AGC